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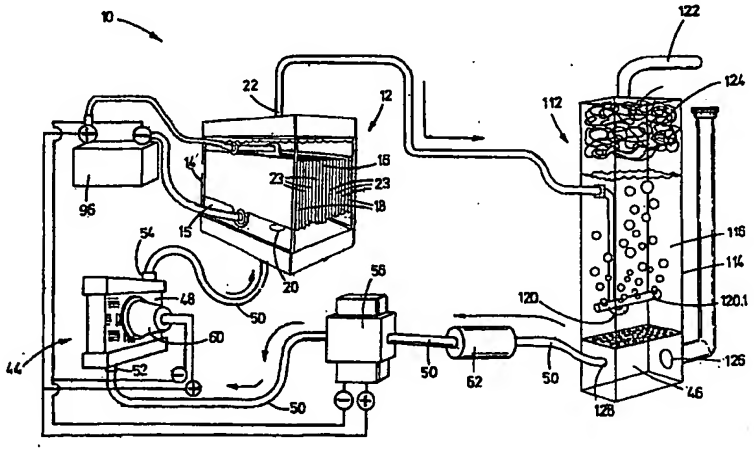
(54) Title: METHOD AND APPARATUS FOR PRODUCING COMBUSTIBLE FLUID



(57) Abstract: This invention provides a method and apparatus (10) for producing combustible fluid in the form of an oxygen/hydrogen gas mixture. An electrolytic reactor (12) includes spaced electrodes (16) and (18) disposed in a cavity (15) of a housing (14) and exposed to an electrolyte and water solution (46). The electrodes (16) and (18) are in the form of a plurality of parallel extending spaced conductive bodies with a plurality of floating conductors (23) disposed intermediate the electrodes (16) and (18). The apparatus (10) further includes cooling device (44) for cooling the electrolyte (46); a pump (56), disposed in the cooling conduit (50) for circulating the electrolyte (46) over the electrodes and through the apparatus; a filter (62) for filtering the electrolyte (46); a separating device (112), for preventing the combustible fluid in the apparatus (10) from igniting; and an electrical power supply comprising an electricity generating and storing means (96). The applicant has surprisingly found that the efficacy of the apparatus (10) according to the invention is substantially higher than conventional reactors and that relatively much more combustible fluid is produced, using substantially less power with a much smaller reactor.

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METHOD AND APPARATUS FOR PRODUCING COMBUSTIBLE FLUID

INTRODUCTION AND BACKGROUND TO THE INVENTION

This invention relates to a method and apparatus for producing combustible fluid and to internal combustion engines and vehicles provided with such apparatus. More particularly this invention relates to a method and apparatus for producing hydrogen and oxygen gas from water through a process of electrolysis.

In this specification, the term "floating conductor" includes within its scope a conductor, which is not directly connected to an electrical current by a solid conductor, or which is connected to an electrical current of a relatively lower potential than associated electrodes.

Further in this specification, the term "combustible fluid" includes within its scope combustible gas containing predominantly hydrogen and oxygen.

USA patent number 4,271,793 discloses an internal combustion engine of the type having a fuel feed system for feeding a fuel air mixture to combustion chambers. An electrical generating and storage system for generating and providing electrical energy to the internal combustion engine is connected to an electrolytic cell for producing hydrogen and oxygen. The cell is provided with a housing; an anode; a cathode; and an electrolyte. The electrolytic cell thus

generates hydrogen and oxygen when the internal combustion engine is running. A gas feed conduit connects the electrolytic cell to the internal combustion engine for feeding the hydrogen and oxygen to the combustion chambers of the engine along with the fuel air mixture from the fuel feed system.

Various other apparatus for producing combustible fluids are known, such as those described in the specifications of USA patents 4,023,545; 4,271,793; 5,105,773; 5,176,809; and 5,450,822 as well as the apparatus disclosed in DE 3018717; RU 2046196; JP 10001684; FR 2,757,567; and DE 19636141.

The above apparatus all suffer from one disadvantage or the other, namely that they are either too bulky or their production rate is insufficient to provide adequate combustible fluid to drive an internal combustion engine at power levels at which motor vehicles conventionally operate.

In general, the known systems are therefore ineffective to produce sufficient and controllable quantities of a hydrogen/oxygen gas mixture to drive a conventional internal combustion engine continuously or alternatively to economically and sufficiently increase the combustion efficiency of such engines when used in conjunction with fuel, or further alternatively to produce sufficient quantities of hydrogen and oxygen for other uses. This is *inter alia* owing to:

- inefficient cooling of the electrolyte;
- insufficient electrode surface areas;
- separation of the hydrogen and the oxygen;
- either too high or too low pressure ranges;
- insufficient circulation of the electrolyte inside the electrolytic cell;
- operation at relatively too high (and possibly lethal) voltages;
- insufficient harvesting of gas from the electrodes;
- insufficient flow of gas along a feed line from the electrolytic cell to the engine/point of use;
- inability to remove impurities from the electrolyte;
- erosion of sacrificial anodes;
- deposits forming on electrodes;
- engine knock due to premature ignition;
- inefficient control over energy input resulting in an unfavourable ratio between energy input relative to output;
- insufficient cooling or drying of the produced gas;
- ineffective flame arresting; and/or
- insufficient control of the electrolyte level.

OBJECT OF THE INVENTION

It is therefore an object of the present invention to provide a method and apparatus for producing combustible fluid and devices provided with such

apparatus, with which the aforesaid disadvantages can be overcome or at least minimised.

SUMMARY OF THE INVENTION

According to a first aspect of the invention there is provided apparatus for producing combustible fluid comprising:

- a housing defining a cavity for containing an electrolyte;
- at least two spaced electrodes exposed inside the cavity and for producing a combustible fluid from the electrolyte on application of an electrical current to the electrodes; and
- at least one floating conductor disposed intermediate the electrodes.

The electrodes and conductor may comprise bodies of conductive material having parallel extending faces, the arrangement being such that the respective diameters of the parallel extending faces of the electrodes and conductor increase gradually from the one electrode to the other.

The housing may be provided with an electrolyte inlet and a fluid outlet.

The housing may define a passage for the electrolyte extending through the cavity from the electrolyte inlet to the fluid outlet.

The electrodes and conductor may be elongate and may be orientated inside the passage with their longitudinal axes extending transversely the passage.

The apparatus may further include circulating means for moving the electrolyte along the passage over the electrodes and conductor.

The apparatus may further be provided with an electrolyte cooling device for cooling the electrolyte.

The circulating means may circulate the electrolyte through the apparatus via the electrolyte cooling device.

The combustible fluid produced in the passage may escape from the housing in the form of a mixture of combustible gas and electrolyte and the apparatus may include a separating device connected to the fluid outlet of the housing, for separating the combustible gas and electrolyte mixture.

The separating device may include a gas cooling means for cooling the combustible gas.

The separating device may further include a drying means for drying the combustible gas.

The separating device may be provided with a flame arresting device for preventing combustion of the combustible fluid inside the apparatus.

The gas cooling means, separating device, flame arresting device and drying means may form a unit comprising a hollow body for containing a cooling liquid, the arrangement being such that the combustible gas is separated from the electrolyte, cooled and dried while moving through the cooling liquid.

The hollow body may be provided with a fluid inlet for the combustible gas and electrolyte mixture and a gas outlet for the separated, cooled and dried combustible gas.

The gas outlet may extend through the flame arresting device.

The fluid inlet may be disposed below the level of the cooling liquid and may comprise a manifold.

The flame arresting device may comprise a mass of inert fibres.

Said gas outlet may communicate with a device utilising combustible fluid.

Said gas outlet may alternatively be connected to a reservoir for storing the combustible fluid.

Further according to the invention, one of the electrodes provides the housing or alternatively the electrodes are disposed inside the housing.

Yet further according to the invention, the floating conductor is a first conductor and a plurality of other spaced apart floating conductors are disposed intermediate the electrodes.

The respective spaces between adjacent conductors and between the conductors and the adjacent electrodes may be equal.

Further according to the invention, the electrodes are first and second electrodes and the apparatus includes a third electrode, which is disposed on an opposite side of the second electrode than the first electrode.

The first and third electrodes may have the same polarity and the second electrode may have an opposite polarity.

A plurality of floating conductors may be disposed intermediate the second and third electrodes.

Further according to the invention, the apparatus is provided with a power supply selected form the group consisting of constant DC, pulsed DC and half wave AC.

The power supply may provide a potential of between 1V and 48V and a current between 1A and 50A.

Yet further according to the invention, the electrolyte is in the form of a solution of a catalyst such as sodium carbonate (Na_2CO_3) and sodium hydroxide (NaOH) in water.

Even further according to the invention, the apparatus includes a controller for selectively controlling the supply of electricity to the electrodes, the arrangement being such that the controller is adapted to supply progressively more power to progressively more electrodes as relatively more combustible fluid is required.

Even further according to the invention, the apparatus is provided with a vacuum pump for removing formed combustible gas from the electrodes.

Even further according to the invention, the apparatus includes a filter device for filtering the electrolyte.

Further according to the invention, the apparatus includes a level control means for controlling the level of the electrolyte, thus ensuring that the electrodes and conductors are continuously submerged in electrolyte.

According to a second aspect of the invention there is provided a method of producing combustible fluid including the steps of:

- providing an electrolyte;
- disposing at least two spaced electrodes in the electrolyte;
- disposing at least one floating conductor in the electrolyte intermediate the electrodes; and
- applying an electrical current to the electrodes to produce combustible fluid from the electrolyte.

The method may include the further step of commutating the polarity of the electrodes.

The combustible fluid may be produced in the form of a mixture of combustible gas and liquid and the method may include the further step of separating the mixture.

The method may include the further step of drying the combustible gas.

The method may include the further step of cooling the combustible gas.

According to a third aspect of the invention there is provided an internal combustion engine, which is adapted to be driven at least partially by a supply of combustible fluid emanating from the apparatus according to the first aspect of the invention.

According to a fourth aspect of the invention there is provided a vehicle provided with an internal combustion engine according to the third aspect of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention will now be described further by way of non-limiting examples with reference to the accompanying drawings wherein:

figure 1 is a diagrammatical perspective view of apparatus according to a first embodiment of the invention, for producing combustible fluid;

figure 2 is a perspective view of an electrolytic reactor of the apparatus of figure 1;

figure 3 is a side view of the reactor of figure 2;

figure 4 is a top view of the reactor of figure 2;

figure 5 is a diagrammatical perspective view of a separating device of the apparatus of figure 1;

figure 6 a top view of an alternative electrode arrangement of the reactor of figure 2;

figure 7 is a schematic representation of a further alternative electrode arrangement of the reactor of figure 2; and

figure 8 is a schematic representation of yet another alternative electrode arrangement of the reactor of figure 2.

DESCRIPTION OF PREFERRED EMBODIMENTS OF THE INVENTION

Referring to figure 1, an apparatus according to a first embodiment of the invention for producing a combustible fluid, is generally designated by reference numeral 10.

The apparatus 10 includes an electrolytic reactor 12 for generating a combustible fluid, in the form of a combustible oxygen/hydrogen gas mixture, from a solution of a suitable catalyst in water. It will be appreciated that the gas mixture can be applied in a virtually unlimited number of applications and devices utilising combustible gas.

Referring further to figures 2 to 4, the reactor 12 includes a housing 14 defining a cavity in the form of a passage 15, for containing a suitable electrolyte 46; a central cathode 16; and two anodes 18 disposed on opposite sides of the cathode 16. The electrodes 16 and 18 are disposed in the housing 14 and are exposed to the electrolyte 46 in the passage 15. The housing 14 is provided

with an electrolyte inlet 20, and a fluid outlet 22. The electrolyte inlet 20 is disposed towards a lower region of the housing 14 and the fluid outlet 22 is disposed towards an upper region of the housing 14.

The housing 14 is also provided with a level control means (not shown) for controlling the level of the electrolyte 46 in the passage 15. This ensures that the electrodes 16 and 18 are continuously submerged in electrolyte 46.

The electrodes 16 and 18 are in the form of a plurality of parallel extending spaced conductive bodies, each defining two opposite faces. A plurality of floating conductors 23 are disposed intermediate the cathode 16 and the anodes 18 but are not in direct contact with the electrodes 16 and 18 nor to a power supply via electrical conductors. The sides of the conductors 23 are connected to each other by a side wall of the housing 14 (shown in figure 4), to limit the flow path of the electrolyte through the spaces between the conductors 23.

Referring to figure 6, the arrangement of the electrodes 16a and 18a and conductors 23a could alternatively be such that the diameters of their parallel extending faces increase gradually from the cathode 16a to the anode 18a. It will be appreciated that the polarity of the electrodes 16a or 18a may optionally be commutated to remove unwanted deposits.

Referring again to figures 2 to 4, the electrodes 16 and 18 and conductors 23 are elongate and are orientated inside the passage 15 with their longitudinal axes extending transversely to the passage 15.

The housing 14 is filled with an electrolyte 46 to cover the electrodes 16 and 18 and the conductors 23. The electrolyte 46 comprises a solution of an catalyst such as sodium bicarbonate or sodium hydroxide in water.

Referring again to figure 1, the apparatus 10 further includes a cooling device 44 for cooling the electrolyte 46, comprising a radiator 48 or the like having an inlet 52 and an outlet 54. The outlet 54 communicates with the inside of the housing 14 via a cooling conduit 50.

A circulating means in the form of a pump 56 is disposed in the cooling conduit 50 for circulating the electrolyte 46 along the conduit 50 through the radiator 48. The cooling means further includes an electrical fan 60 for cooling the radiator 48. A filter 62, is also provided for filtering the electrolyte 46.

Referring additionally to figure 5, the fluid outlet 22 of the reactor 12 is connected to a separating device 112. The separating device 112 comprises an elongate hollow body 114 defining a chamber 116 for housing the electrolyte 46; a fluid inlet 120 for a mixture of electrolyte and combustible gas; a gas outlet 122 for combustible fluid; a flame arresting device 124 for preventing the

combustible fluid in the apparatus 10 from igniting; a water inlet 126; and an electrolyte outlet 128. The electrolyte outlet 128 is connected to the inlet 52 of the cooling means 44 via the conduit 50, pump 56 and filter 62. The flame arresting device is in the form of a mass of inert fibres.

The fluid inlet 120 is connected to the fluid outlet 22 of the housing 14 and is disposed towards a lower region of the hollow body 114. The fluid inlet 120 is further provided with a submerged manifold 120.1. The arrangement is such that the combustible gas is released from the mixture of liquid and gas in the form of small bubbles in the electrolyte 46, wherein the combustible gas is cooled and dried.

The gas outlet 122 is disposed towards an upper region of the hollow body 114 and is connected to a carburettor or air inlet system (not shown) of an internal combustion engine. The combustible gas passes through the flame arresting device 124 prior to flowing to the engine and accidental combustion of the gas in the apparatus 10 is thus restricted.

The apparatus 10 further includes an electrical power supply comprising an electricity generating and storing means 96 and a controller (not shown) for controlling the supply of electrical power to the electrodes 16 and 18

The generating and storing means 96 is in the form of a battery, which is charged by an alternator (not shown) of an internal combustion engine and the controller (not shown) controls the supply of electrical power to the electrodes 16 and 18. The arrangement is such that when there is a need for relatively more power, for example when the vehicle drives uphill, all the electrodes 16 and 18 are provided with electricity. When relatively less power is required; such as when the vehicle slows down or drives downhill, the supply of electrical current to one of the electrodes 16 and 18 are disconnected, to slow down the production of combustible fluid by the reactor 12.

In use, the passage 15 is filled with ordinary tap water and the catalytic electrolyte introduced into the housing 14. The catalytic electrolyte is introduced only once, as it is not consumed during the electrolytic reaction.

The controller (not shown) supplies power to the electrodes 16 and 18 in accordance with the energy needs of the engine. The electrodes 16 and 18 produce a combustible gas in the form of a mixture of hydrogen and oxygen from the water through an electrolytic dissociation of the water molecules. The combustible gas escapes the housing 14 in a mixture with the electrolyte. As the housing 14 remains filled with the electrolyte, the electrolyte and combustible gas mixture is pumped from the fluid outlet 22 to the manifold 120.1, where the combustible gas is released in the form of fine bubbles. In the separating device 112, the bubbles of combustible gas are dried and cooled

and the combustible gas separated from the electrolyte. The combustible gas accumulates in the top of the separating device 112 and flows out via the flame arresting device 124, passing through the gas outlet 122 for further use.

The electrolyte accumulates in the bottom of the separating device 112, and is circulated and cooled through the cooling conduit 50 via the radiator 48 to the reactor 12.

The applicant has surprisingly found that the efficacy of the apparatus 10 according to the invention is substantially higher than conventional reactors and that relatively much more combustible fluid is produced, using substantially less power with a much smaller reactor. The applicant believes that this is primarily due to the location of the floating conductors 23 intermediate the electrodes 16 and 18 and secondarily due to the gradual increase in the diameter of the electrodes 16 and 18 and conductors 23.

Referring to figures 7 and 8, electrode and floating conductor configurations according to alternative embodiments of the invention is generally designated by reference numerals 16b, 18b, 23b and 16c, 18c and 23c respectively.

Although this invention was described with reference to an internal combustion engine, it will be appreciated that the combustible gas can be used by any device requiring combustible gas to operate.

The applicant has further found that by providing a vacuum pump to suck out a mixture of combustible gas and electrolyte from the spaces between the electrodes and conductors, and by cooling the electrolyte, a more efficient production is obtained.

It will be appreciated that variations in detail are possible with a method and apparatus according to the invention for producing combustible fluid and internal combustion engines and vehicles provided with such apparatus without departing from the scope of the appended claims.

CLAIMS

1. Apparatus for producing combustible fluid comprising a housing defining a cavity for containing an electrolyte; a plurality of spaced electrodes exposed inside the cavity and for producing a combustible fluid from the electrolyte on application of an electrical current to the electrodes; and at least one floating conductor disposed intermediate the electrodes.

2. Apparatus according to claim 1 wherein the electrodes and conductor comprise bodies of conductive material having parallel extending faces, the arrangement being such that the respective diameters of the parallel extending faces of the electrodes and conductor increase gradually from the one electrode to the other.

3. Apparatus according to claim 1 or claim 2 wherein the housing is provided with an electrolyte inlet and a fluid outlet and wherein the housing defines a passage for the electrolyte extending through the cavity from the electrolyte inlet to the fluid outlet.

4. Apparatus according to claim 3 wherein the electrodes and conductor are elongate and wherein they are orientated inside the passage with their longitudinal axes extending transversely the passage.

5. Apparatus according to claim 3 or claim 4 which further includes circulating means for moving the electrolyte along the passage over the electrodes and conductor.

6. Apparatus according to claim 5 which is further provided with an electrolyte cooling device for cooling the electrolyte.

7. Apparatus according to claim 6 wherein the circulating means further circulates the electrolyte through the apparatus via the electrolyte cooling device.

8. Apparatus according to any one of claims 5 to 7 wherein combustible fluid produced in the passage escapes from the housing in the form of a mixture of combustible gas and electrolyte and wherein the apparatus includes a separating device connected to the fluid outlet of the housing, for separating the combustible gas and electrolyte mixture.

9. Apparatus according to claim 8 wherein the separating device includes a gas cooling means for cooling the gas.

10. Apparatus according to any one of claims 8 or 9 wherein the separating device includes a drying means for drying the combustible gas.

11. Apparatus according to any one of claims 8 to 10 wherein the separating device is provided with a flame arresting device for preventing combustion of the combustible fluid inside the apparatus.

12. Apparatus according to claim 11 insofar as it is dependant on both claims 9 and 10 wherein the gas cooling means, separating device, flame arresting device and drying means forms a unit comprising a hollow body for containing a cooling liquid, the arrangement being such that the combustible gas is separated from the electrolyte, cooled and dried while moving through the cooling liquid.

13. Apparatus according to claim 12 wherein the hollow body is provided with a fluid inlet for the combustible gas and electrolyte mixture and a gas outlet for the separated, cooled and dried combustible gas, the gas outlet extending through the flame arresting device.

14. Apparatus according to claim 13 wherein the fluid inlet, in use, is disposed below the level of the cooling liquid and comprises a manifold.

15. A separation device according to any one of claims 11 to 14 wherein the flame arresting device comprises a mass of inert fibres.

16. Apparatus according to claim 15 insofar as it is dependant on claim 13 wherein said gas outlet communicates with a device utilising combustible fluid.

17. Apparatus according to claim 15 insofar as it is dependant on claim 13 wherein said gas outlet is connected to a reservoir for storing the combustible fluid.

18. Apparatus according to any one of the preceding claims wherein the electrodes provides the housing.

19. Apparatus according to any one of claims 1 to 17 wherein the electrodes are disposed inside the housing.

20. Apparatus according to any one of the preceding claims wherein the floating conductor is a first conductor and wherein a plurality of other spaced apart floating conductors are disposed intermediate the electrodes.

21. Apparatus according to claim 20 wherein the respective spaces between adjacent conductors and between the conductors and the adjacent electrodes are equal.

22. Apparatus according to any one of the preceding claims wherein the electrodes are first and second electrodes and wherein the apparatus includes a third electrode, which is disposed on an opposite side of the second electrode than the first electrode.

23. Apparatus according to claim 22 wherein the first and third electrodes have the same polarity, in use, and the second electrode has an opposite polarity.

24. Apparatus according to claim 22 or 23 wherein a plurality of floating conductors are disposed intermediate the second and third electrodes.

25. Apparatus according to any one of the preceding claims provided with a power supply selected form the group consisting of constant DC, pulsed DC and half wave AC.

26. Apparatus according to claim 25 wherein the power supply provides a potential of between 1V and 48V and a current of between 1A and 50A.

27. Apparatus according to any one of the preceding claims wherein the electrolyte comprises a catalyst selected from the group consisting of sodium carbonate (Na_2CO_3) and sodium hydroxide (NaOH) in water.

28. Apparatus according to any one of the preceding claims which includes a controller for selectively controlling the supply of electricity to the electrodes.

29. Apparatus according to claim 28 wherein the arrangement is such that the controller is adapted to supply progressively more power to progressively more electrodes as relatively more combustible fluid is required.

30. Apparatus according to any one of the preceding claims, which is further provided with a vacuum pump for removing formed combustible gas from the electrodes.

31. Apparatus according to any one of the preceding claims which further includes a filter device for filtering the electrolyte.

32. Apparatus according to any one of the preceding claims, which further includes a level control means for controlling the level of the electrolyte, the arrangement being such that the level control means ensures that the electrodes and conductors are continuously submerged in electrolyte.

33. A method of producing combustible fluid including the steps of:

- providing an electrolyte;
- disposing at least two spaced electrodes in the electrolyte;
- disposing at least one floating conductor in the electrolyte intermediate the electrodes; and
- applying an electrical current to the electrodes to produce combustible fluid from the electrolyte.

34. A method according to claim 33 which includes the further step of commutating the polarity of the electrodes

35. A method according to claim 33 or 34 wherein the combustible fluid is produced in the form of a mixture of combustible gas and liquid, the method including the further step of separating the mixture.

36. A method according to any one of claims 33 to 35, which includes the further step of drying the combustible gas.

37. A method according to any one of claims 33 to 36, which includes the further step of cooling the combustible gas.

38. An internal combustion engine, which is adapted to be driven at least partially by a supply of combustible fluid emanating from the apparatus according to any one claims 1 to 32.

39. A vehicle provided with an internal combustion engine according to claim 38.

40. Apparatus for producing combustible fluid substantially as herein described and as illustrated in the accompanying drawings.

41. A method of producing combustible fluid substantially as herein described with reference to the accompanying drawings.

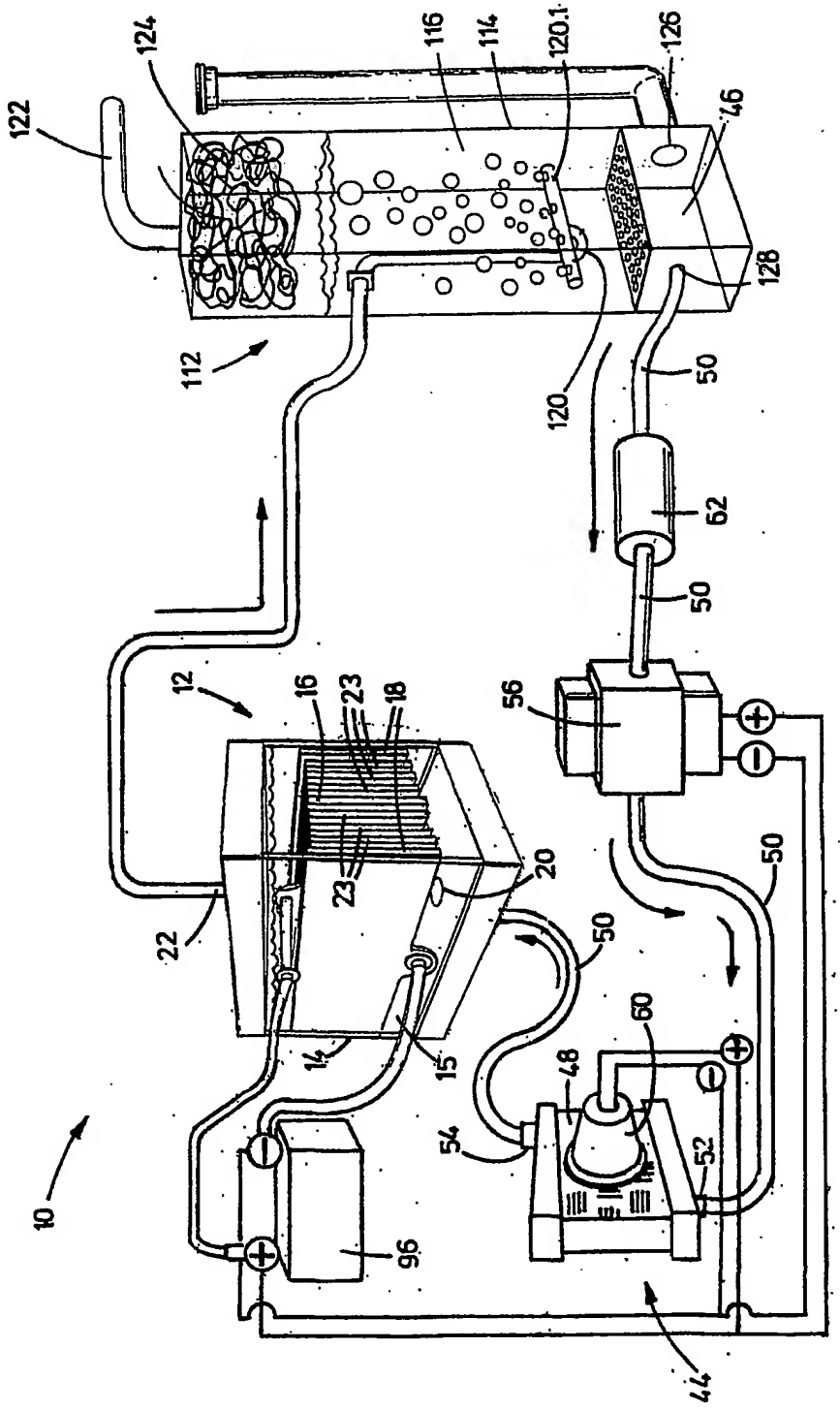
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FIGURE 1

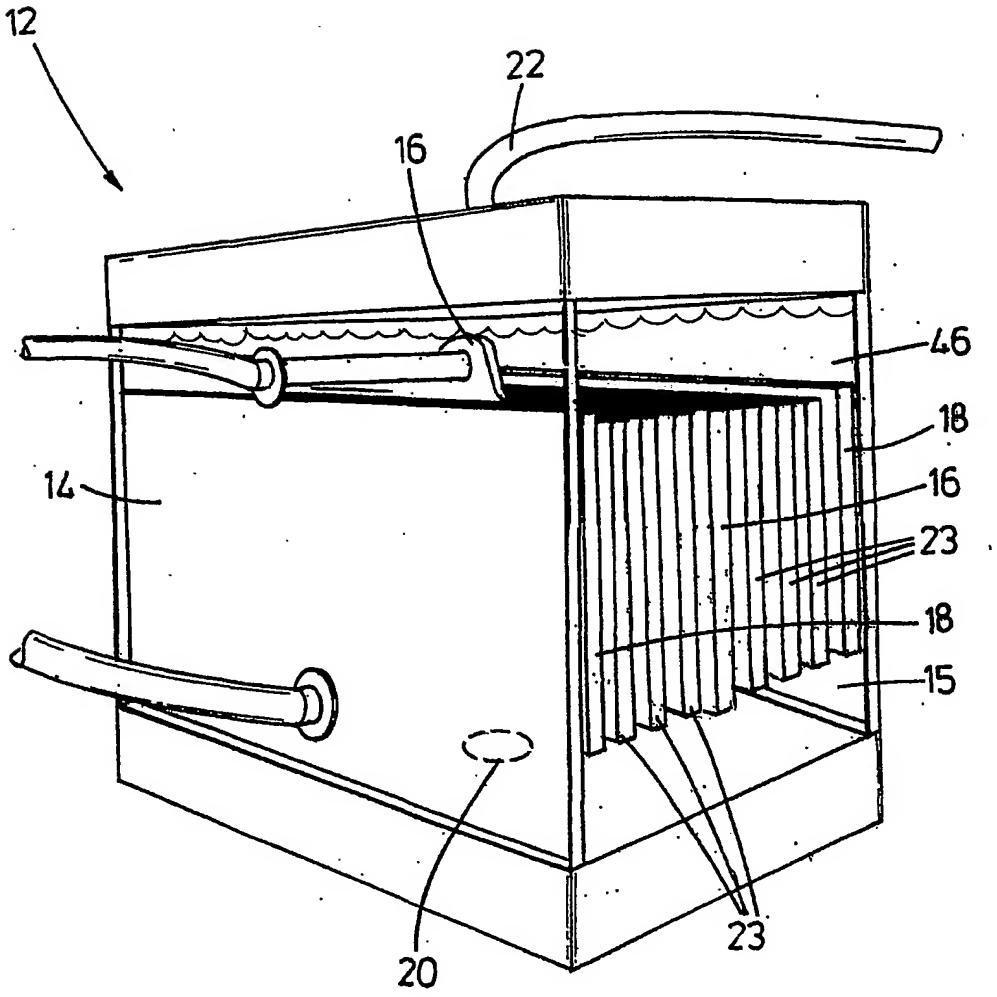

FIGURE 2

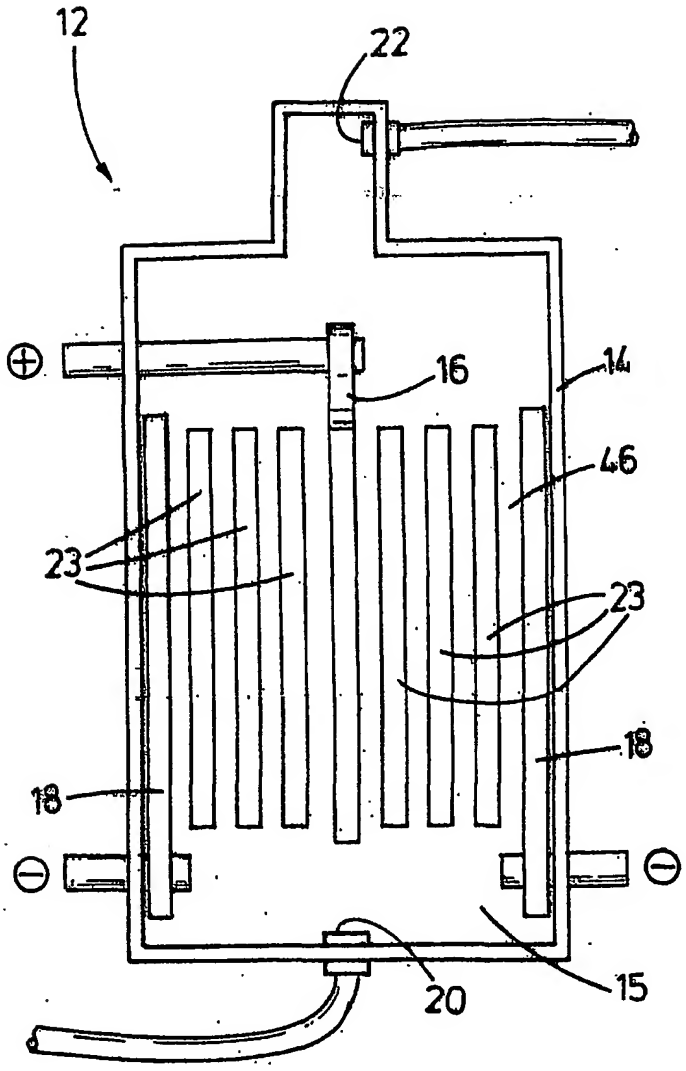

FIGURE 3

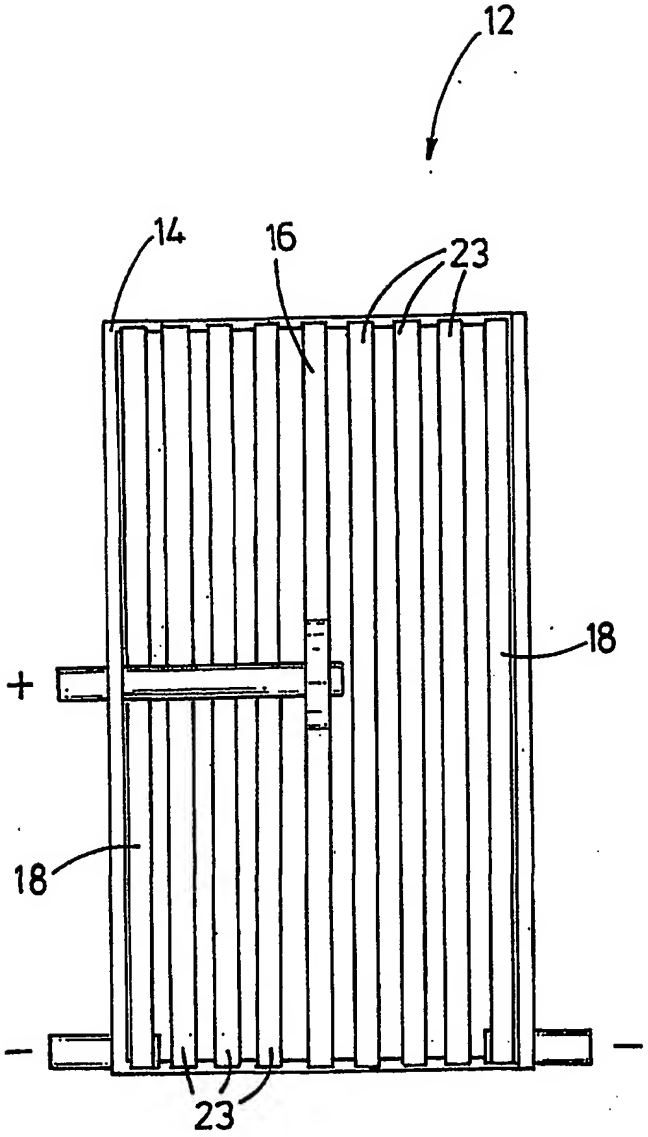

FIGURE 4

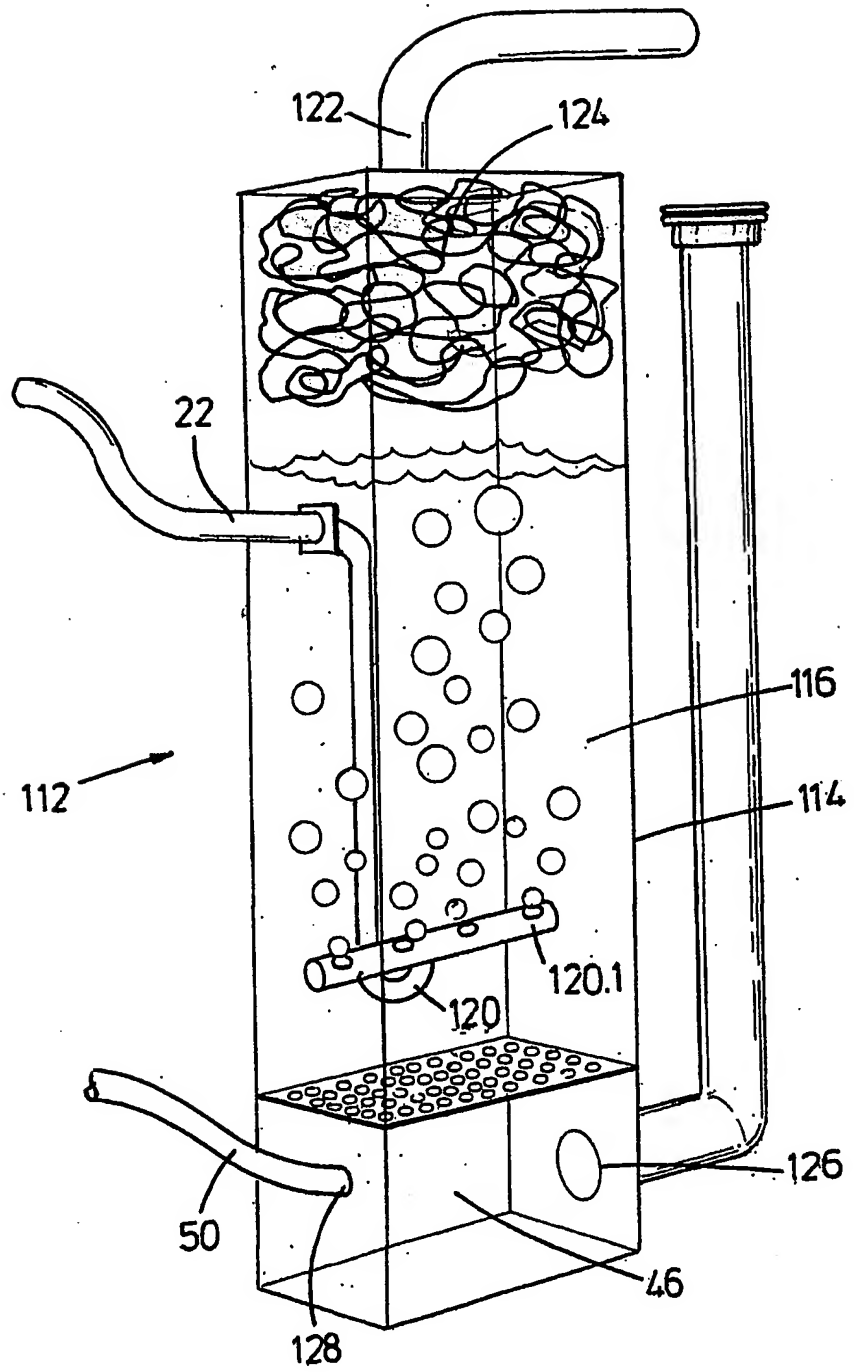

FIGURE 5

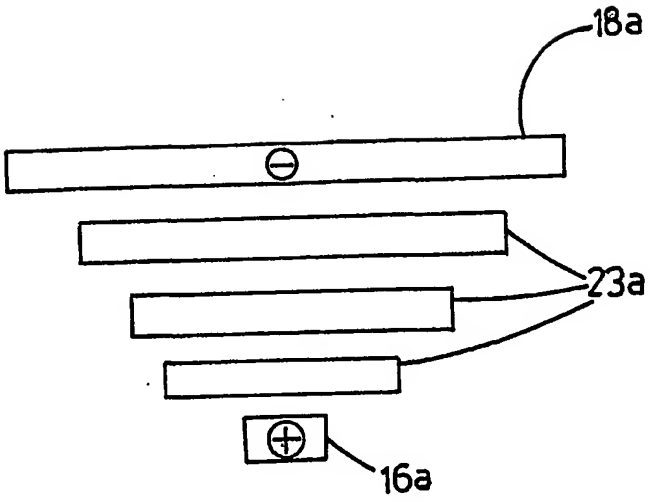

FIGURE 6

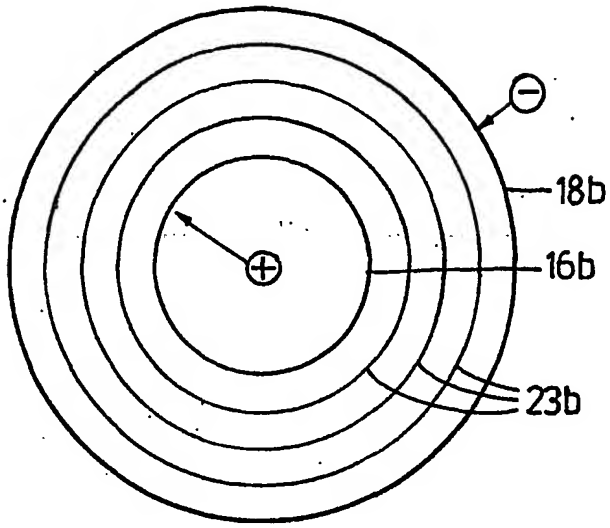

FIGURE 7

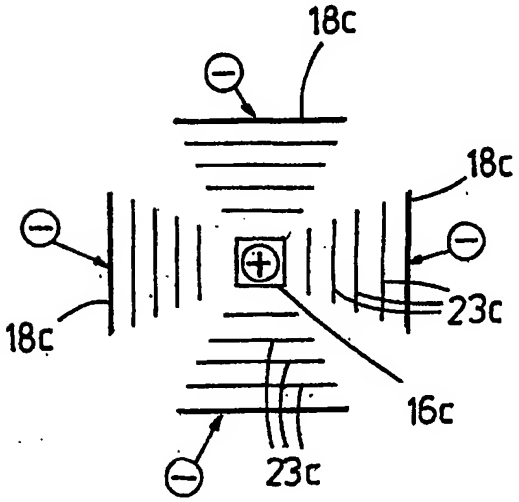

FIGURE 8